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FOOT & ANKLE INTERNATIONAL

Consistency of Visual Assessments of Arch Height among Clinicians*

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ABSTRACT

Flat feet and high-arched feet have been cited as risk factors for musculoskeletal injury and functional problems among runners and other active individuals, although there are no established quantitative definitions or measures for assessing either condition. As part of a larger study, four-plane photographs were made of the weightbearing right foot of 246 young male Army trainees. These photographs were independently evaluated by six clinicians and rated on a scale of clearly flat-footed (category 1) to clearly high arched (category 5). There was much interclinician variability in the assessments, even for extremes of foot type. The probability of a clinician assessing a foot as clearly flat, given that another clinician had rated the foot as clearly flat, ranged from 0.32 to 0.79, with a median probability of 0.57, while for clearly high-arched feet, probabilities ranged from 0.0 to 1.00, with a median of 0.17. These findings demonstrate the need for objective standards and quantitative methods of evaluating foot morphology.

INTRODUCTION

Flat feet and high arches are cited as risk factors for injuries and functional problems among runners and other active persons.[1,3,7,11,14,15] While most of the literature regarding this matter is based on clinical opinion and case series, recent findings based on prospective epidemiologic evaluation of young men in military populations indicate that foot type is associated with the risk of training injury.[4,5] Both of these studies[4,5] report that those with flatter feet were at lowest risk, and higher-arched individuals had substantially and significantly higher risk of musculoskeletal injury.

There is considerable opinion offered on preventive and treatment strategies for conditions associated with these foot types, but there is little substantive or standardized guidance for making reliable or quantitative assessments of the medial longitudinal arch.[2,6,13] To conduct a complete clinical evaluation of a subject's feet, whether they are normal, flat, or high arched, a detailed history, physical examination, and possibly radiographic examinations are required.[10] This is obviously a time-consuming affair, and could be expected to take up to 1 hr per subject to complete. The impracticality of examinations of this type in most epidemiologic research is readily apparent.

As part of a larger project to evaluate types, incidence, and risk factors for lower extremity musculoskeletal injuries among U.S. Army Infantry trainees,[12] this research was conducted to determine whether interclinician variability was sufficiently low to develop a photograph-based method of arch assessment, using the same photographs used in the epidemiologic assessment of arch height.[4] If clinicians can reliably evaluate foot morphology using four-plane color slides of the weightbearing foot, it may be possible to develop a useful in-office method of clinical assessment. This study did not evaluate the ability of clinicians to predict injury based on foot morphology.

MATERIALS AND METHODS

Population

The subjects in this report are a subset of a group of 303 male Army infantry trainees evaluated for factors predictive of training injuries. The methods and materials, population, and injuries have been described.[12]

Foot Photographs

Photographs were taken of the right weightbearing foot of 246 soldiers. Each subject stood on a specially

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built platform while his right foot was photographed. An acrylic plate was used for the shelf of the platform to allow a distortion-free view of the plantar surface of the foot. Attached to the platform were three mirrors set at angles to allow anterior, posterior, medial, and plantar views of the foot in one photograph. Mirrors were aligned before and during each photographic session through the use of a cube of known dimension. The alignment was adjusted so that only one side of the cube was visible through each mirror when the apparatus was viewed through the camera. A foot rest was attached to the apparatus so that subjects could balance themselves with their left foot during the photographic procedure. Figures 1 and 2 are photographs of the equipment.

A 35-mm camera was positioned to allow a full view of the platform and mirrors with as little background as possible. Camera position was determined by alignment through the viewfinder with the platform, and distance was kept constant with a gauge chain.

Each subject was instructed individually to align the medial aspect of his right foot with a reference line on the platform, and to place full body weight on the right leg. They were requested to use the left foot, on the foot rest, only to maintain balance. The photographer then checked to make certain the leg was approximately perpendicular to the plate, and that the plantar pressure pattern of the foot was evenly distributed.

The foot was then marked with black ink at the center of the lateral and medial metatarsophalangeal joint, inferior medial aspect of the navicular, and inferior center aspect of the medial and lateral malleoli. The soft tissue arch height was marked using a polystyrene block with felt material glued on one edge to hold powdered chalk. The felt-covered edge was lightly placed against the medial aspect of the metatarsophalangeal joint, and the lower aspect of the block was held against the surface of the platform. Sliding the block along the arch area to the heel provided an indication of the soft tissue arch height. The photograph was then taken. One investigator (J.R.R.) marked all anatomic locations and took all photographs. Figure 3 is an example of one of the flattest 20% (based on methods used in Ref. 4), while Figure 4 shows one of the 20% highest arched feet.

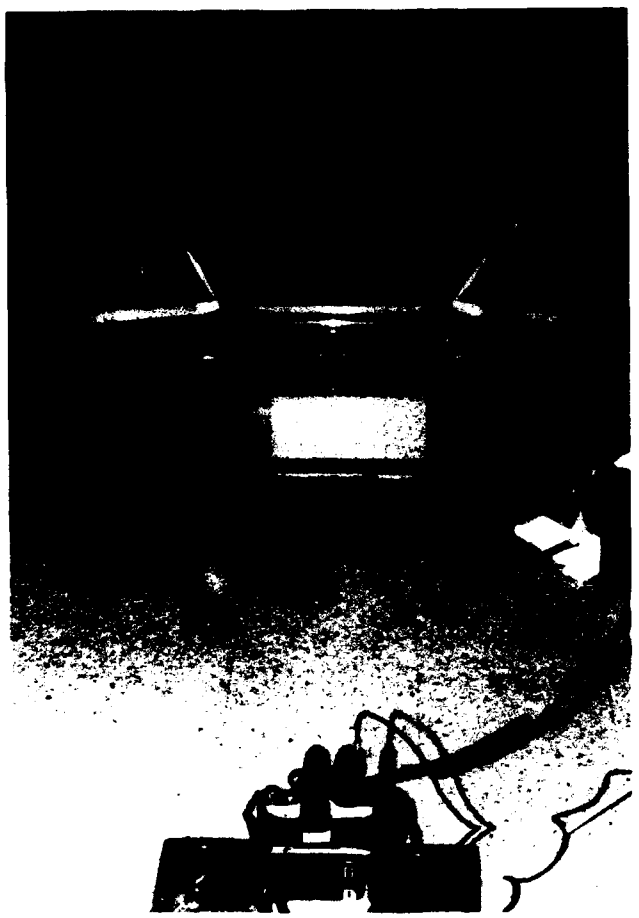

Fig. 1. Equipment for taking four-plane photographs of feet.

Fig. 2. View of subject standing on equipment.

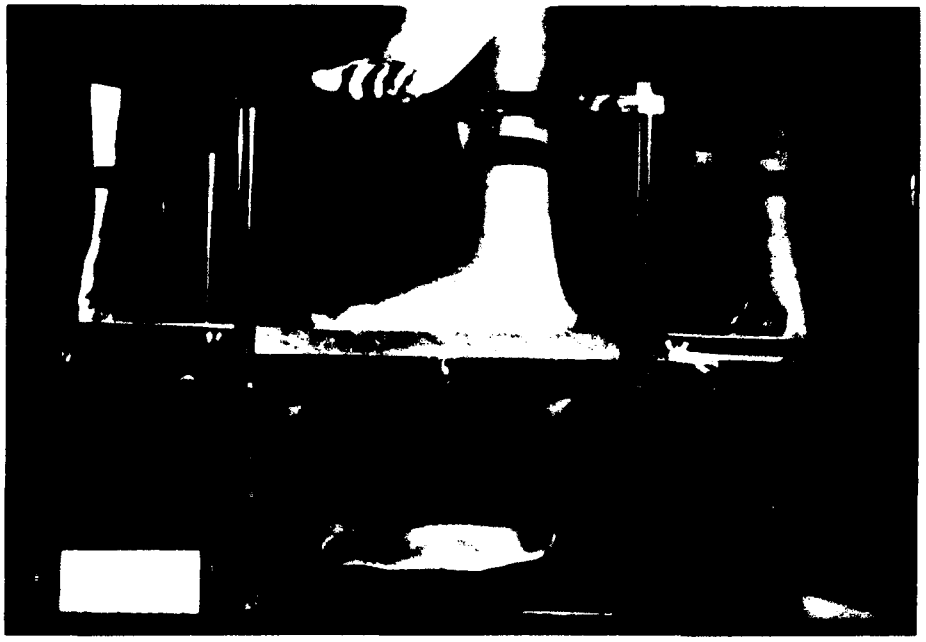

Fig. 3 Subject from the flattest quintile of study group.

Fig. 4 Subject from the highest-arch quintile of study group.

Clinician Assessment

The assessments were conducted by four orthopaedic surgeons and two podiatrists, all of whom were either staff or residents in training at Walter Reed Army Medical Center. By agreement with the clinicians, no individual or professional identification was presented in reports.

Before evaluating the study slides, the clinicians reviewed 40 slides from persons who were not study subjects and discussed the criteria they would use to assess the feet. The evaluation consisted of a five-point scale, with choices ranging from clearly flat-footed (category 1) to clearly high arched (category 5), with category 3 defined as normal. Each clinician viewed each slide and recorded his assessment for each subject. Evaluations by all clinicians were conducted independently and without discussion.

Analytical Methods

Overall differences between individual clinicians were examined using Kruskal-Wallace nonparametric analysis of variance.[8] The frequency of clinicians rating sub-

TABLE 1
Summary Statistics for Foot Evaluations

Clinician	Mean	Median	SD	Percentage of total evaluations in each category*				
				1	2	3	4	5
1	2.79	3	0.814	10.1	13.7	65.7	8.5	2.0
2	2.63	3	0.775	8.9	27.1	57.9	4.5	1.6
3	2.58	3	0.873	16.5	17.7	57.3	8.1	0.4
4	2.94	3	0.808	7.7	10.1	64.9	14.9	2.4
5	2.21	2	0.689	14.2	52.0	32.5	1.2	0.0
6	2.30	2	0.787	14.6	45.5	35.8	3.3	0.8

* Categories: 1 = clearly flat; 3 = normal; 5 = clearly high arched.

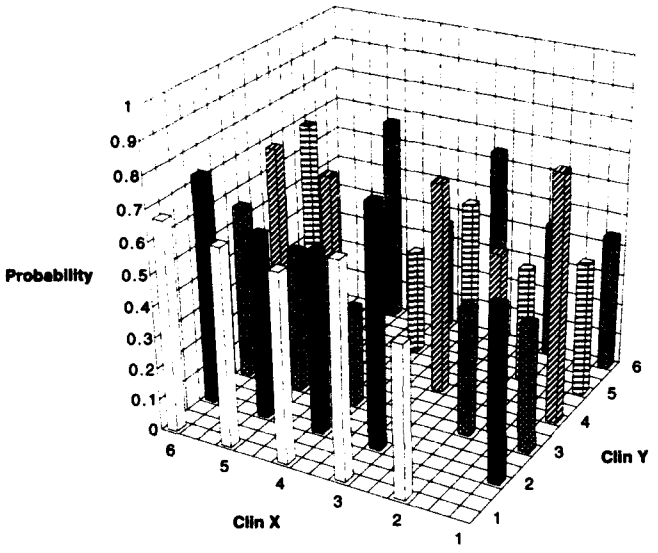

Fig. 5. Probability that a clinician (clin X) rated a soldier's foot as clearly flat, given that another clinician (clin Y) had rated the same soldier's foot as clearly flat.

jects at each category (categories 1–5) was also assessed. The associations between clinicians' evaluations were examined with Kendall's tau.[9] A coefficient of 1.0 indicates perfect agreement between clinicians.

The level of agreement for extreme evaluations was considered through the use of conditional probabilities. A conditional probability is the likelihood that a clinician will evaluate a subject as clearly flat-footed (category 1), given that another clinician has already evaluated that subject as clearly flat-footed (probability clinician X rating = 1 | clinician Y rating = 1). Conditional probability ranges from 0.0 (no agreement) to 1.0 (complete agreement). The conditional probability was calculated for each clinician compared with every other clinician, resulting in 30 comparisons. The conditional probabilities were considered for those evaluated as clearly flat-footed (category 1) and for those evaluated as clearly high arched (category 5), and for those in categories 1 or 2, and 4 or 5.

RESULTS

The summary statistics of evaluations for each clinician are provided in Table 1. Except for three comparisons (clinician 1 compared with clinicians 3 and 4, and clinician 5 compared with clinician 6), all of the clinician's distributions of categories were significantly different from one another.

The overall association between clinical evaluations was evaluated, comparing each clinician's assessment with that of every other clinician. While all tau coefficients were statistically significantly greater than zero ($P < .001$), the median coefficient was 0.35 (ranging from 0.22 to 0.48), and generally indicated a low level of agreement between clinicians.

A more important comparison among clinicians is the level of agreement between clinicians on those subjects who have clearly flat or clearly high-arched feet, which may predispose to pathological conditions. As shown in Figure 5, for those soldiers evaluated by one clinician as having a clearly flat foot, the probabilities of a second clinician rating those same feet as flat ranged from 0.32 to 0.79, with a median probability of 0.57. As seen in Figure 6, clinicians exhibited little agreement on which feet were high arched. The probabilities ranged from 0.00 to 1.00, with a median probability of 0.17.

When the categories were expanded for flat feet (probability clinician X rating = 1 or 2 | clinician Y rating = 1 or 2), the level of agreement improved only marginally, with a median conditional probability of 0.58 for those with an evaluation of 1 or 2; for high-arched feet (probability clinician X rating = 4 or 5 | clinician Y rating = 4 or 5), the median probability was 0.26.

DISCUSSION

Even with anatomic landmarks clearly highlighted and with visualization of the medial, posterior, anterior, and plantar aspects of the foot, there was very poor agreement among clinicians in assessing arch height. Among those at the extremes of the evaluations, the high-

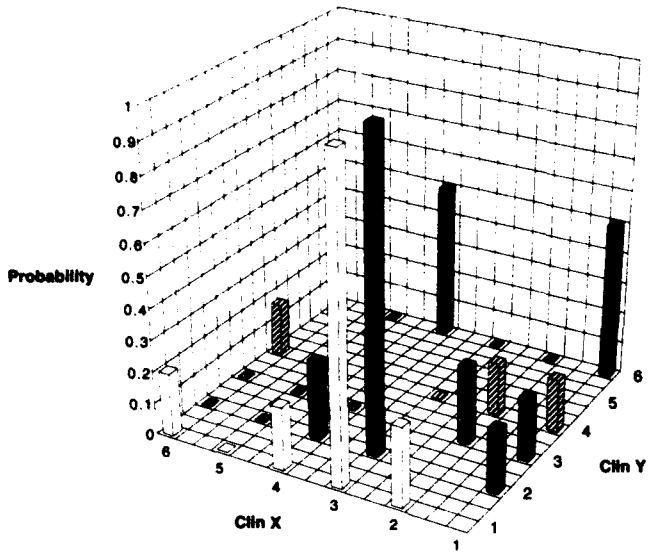

Fig. 6. Probability that a clinician (clin X) rated a soldier's foot as clearly high arched, given that another clinician (clin Y) had rated the same soldier's foot as clearly high arched.

arched foot was predicted much less reliably than the flat-arched foot.

Although some foot types are believed to predispose individuals to injury, few well-designed studies have been conducted to document associations between foot morphology and risk of injury. Two recent prospective studies[4,5] report significant associations between high arches and greater risk of lower extremity musculoskeletal injury among military trainees. The study by Cowan et al.[4] showed an association between high arches and injury risk when foot morphology was objectively measured. The fact that the poorest agreement between clinicians in this present study was for high-arched feet argues strongly for standardized, quantitative measurements of arch height, at least as a screening mechanism.

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